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EUBIONET III—Solutions to biomass trade and market barriers☆,☆☆

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ABSTRACT

The EUBIONET III project has boosted (i) sustainable, transparent international biomass fuel trade, (ii) investments in best practice technologies and (iii) new services on biomass heat sector. Furthermore, it identified cost-efficient and value-adding use of biomass for energy and industry. The aims of this article are to provide a synthesis of the key results of this project. Estimated annual solid biomass potential in the EU-27 is almost 6600 PJ (157 Mtoe), of which 48% is currently utilised. The greatest potential for increased use lies in forest residues and herbaceous biomass. Trade barriers have been evaluated and some solutions suggested such as CN codes for wood pellets and price indexes for industrial wood pellets and wood chips. The analysis of wood pellet and wood chip prices revealed large difference amongst EU countries, but also that on the short term prices of woody and fossil fuels are barely correlated. Sustainable production and use of solid biomass are also deemed important by most European stakeholders, and many support the introduction of harmonised sustainability criteria, albeit under a number of preconditions. The study identified also that a number of woody and agro-industrial residue streams remain un- or underutilised. The estimated European total potential of agro-industrial sources is more than 250 PJ (7.2 Mtoe), the amount of unutilised woody biomass (the annual increment of growing stock) even amounts to 3150 PJ (75 Mtoe). Finally 35 case studies of biomass heating substituting fossil fuels were carried out, showing that the potential to reduce GHG emissions ranges between 90 and 98%, while costs are very similar to fossil fuel heating systems. Overall, we conclude that solid biomass is growing strongly, and is likely to heavily contribute to the EU renewable energy targets in the coming decade.

Contents

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1. Introduction

Solid biomass markets in Europe have developed rapidly over the past decades, yet it has remained difficult to obtain high-quality statistics on e.g. utilisation, prices, trade routes and other data that are important to the industry, policy makers and scientists alike. To change this situation, the EUBIONET—European bioenergy network was established in 1999 and has since then analysed solid biofuel markets in Europe. Also fuel price information and standards have been key areas in the network activities. The current project – EUBIONET III – has continued to work on biomass fuel trade, but also new items like sustainability issues and bioenergy and forest industry have been added to the work programme. EUBIONET has also promoted and collected feedback from industry to support drafting of solid biofuel standards, which are carried out by CEN technical committee 335 and lately also international solid biofuel standardisation under ISO/TC 238. The aims of this article are to provide an overview and synthesis of the key results of this project.

Since the start of the project in 2001, the project has been coordinated by VTT, Finland. Project partners for the last project period (September 2008–August 2011) were the following: Technical Research Centre of Finland VTT (Finland, coordinator), Danish Technological Institute DTI (Denmark), Energy Centre Bratislava ECB (Slovakia), Ekodoma (Latvia), Agency for Renewable Resources FNR (Germany), Swedish University of Agricultural Sciences SLU (Sweden), Brno University of Technology (Czech Rep.), Norwegian University of Life Sciences (Norway), Centre Wallon de Recherches agronomiques CWR-A (Belgium), BLT-HBLuFA Francisco Josephinum FJ-BLT (Austria), European Biomass Association AEBIOM (Belgium), Centre for Renewable Energy Sources CRES (Greece), Utrecht University (Netherlands), University of Florence (Italy), Lithuanian Energy Institute LEI (Lithuania), Imperial College of Science (UK), Centro da Biomassa para a Energia CBE (Portugal), Energy Restructuring Agency ApE (Slovenia) and Andalusian Energy Agency AEA (Spain).

2. Solid biofuel trade and resources

2.1. General

Large amounts of solid biomass are currently produced, traded and used for energy purposes in the European Union, but this trade is largely uncharted. Also, increasing volumes of unrefined and refined biomass are imported from outside the EU to several European countries (see Fig. 1 for the example of wood pellet trade flows). While the traded volumes are most likely in most cases relatively small compared to local production and consumption of solid biomass, biomass trade has shown strong growth in recent years, and there are good reasons to believe that this will continue in the years to come. Especially countries with little domestic biomass resources and high targets for renewable electricity, renewable heat and (eventually 2nd generation) liquid biofuels may increasingly depend on imported solid biomass. On the other hand, countries with ample solid biomass resources are increasingly discovering the international markets for solid biomass, and especially wood pellet plants are frequently built with the main (or sole) purpose of export [1]. However, these new markets are frail, and many barriers are still preventing the further growth. One of the aims of the EUBIONET III project was to identify trade routes, quantify traded volumes and point out barriers and opportunities for trade. The aim of EUBIONET III was also to assess the economically and technically viable volume of solid biomass fuels (woody, herbaceous and fruit biomass) [1].

2.2. Biomass use and potentials

According to EUBIONET III study, 48% of the annual biomass potential (157 Mtoe for biomass excluding biodegradable waste) is currently used in the EU-24 and Norway. The biggest potential lies on forest residues and herbaceous and fruit biomass, equal to almost 50% of the potential (see Figs. 2 and 3). The use of pellets is about 20% higher than production in EU. The trade of pellets is about 1.5 million tons and 85% of imported pellets are from USA, Canada and Russia [1].

The EUBIONET III partners have estimated that the total techno-economical potential is 6577 PJ (157 Mtoe), of which 67% is from woody biomass. According to reported data, the following countries have the lowest total annual biomass resources (<100 PJ): Bulgaria (42 PJ), Belgium (50 PJ), Denmark (34 PJ), Estonia (48 PJ), Lithuania (47 PJ), Slovenia (53 PJ), Slovak Republic (72 PJ), the Netherlands (77 PJ) and Greece (74 PJ). In turn, Germany (1080 PJ), Sweden (841 PJ), Spain (588 PJ), France (574 PJ), Italy (484 PJ) and Finland (428 PJ), are the EU countries endowed with the richest biomass resources (see Fig. 2). Sweden, Finland, Germany and France have largest volumes of forest residues [1].

2.3. Biomass trade barriers and solutions

Biomass trade in Europe has been growing strongly, especially for refined biomass fuels (such as wood pellets). While in many countries, local biomass potentials still remain to be exploited, on the longer term, it is likely that some European countries with a high demand for biomass but little supply may face a shortage of biomass, while others may still have abundant supplies. While so far, only a (very) small part of the total biomass utilised in the EU is traded internationally, this share is rapidly growing. Especially the trade of wood pellets has been growing strongly, and is likely to continue to grow in the years to come. Nevertheless, also other forms of solid biomass e.g. wood chips, waste wood, firewood and agricultural residues are traded, sometimes also in significant quantities. However, these trade flows are much harder to monitor [1].

Based on the viewpoints of biomass traders in many EU countries, the following barriers are currently limiting solid biomass trade [1]:

- Raw material scarcity (especially for the production of wood pellets) is seen as a major bottleneck for the further increase in the

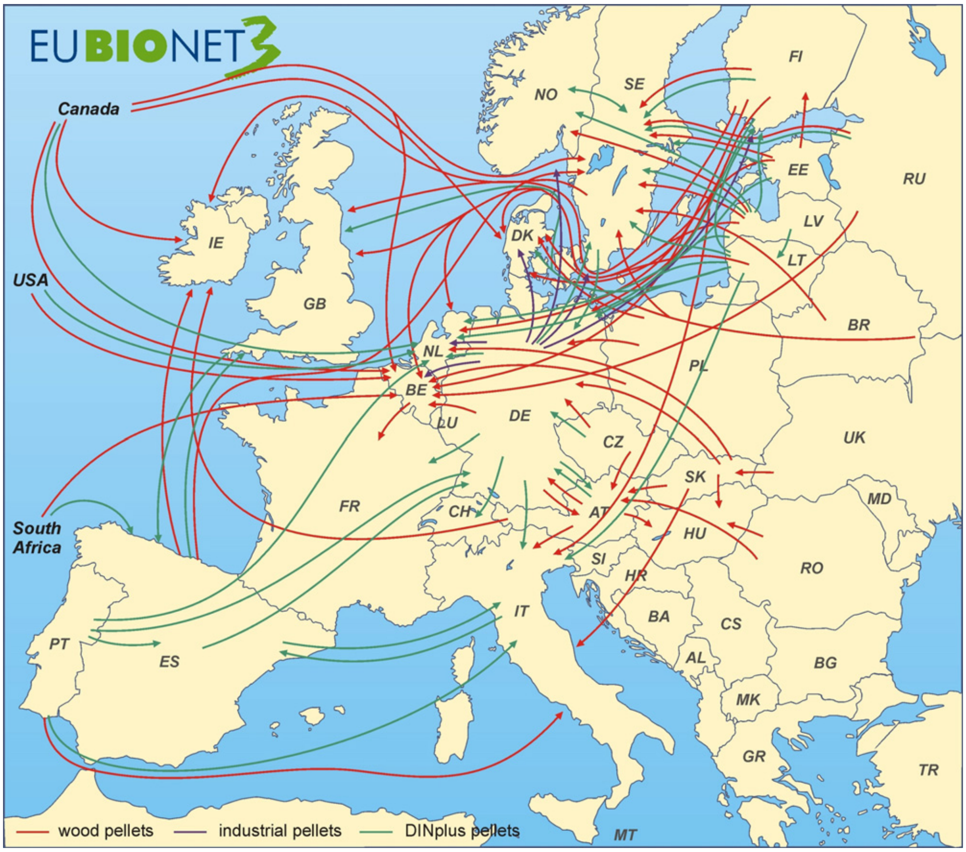


Fig. 1. Trading routes of wood pellets [1].

production and trade of European biomass. At the same time, this shortage may actually increase the import of refined (and unrefined) biomass from outside the EU e.g. from Canada, the USA and North-West Russia.

- Logistical issues, such as bad roads and lack of suitable infrastructures in harbours, are also a major barrier, hampering especially the low-density biomass types.
- Sustainability criteria were seen as an (potential) obstacle by market actors in Germany, the Netherlands and the UK, mainly because it is largely unclear if (and which) solid biomass streams will have to meet sustainability criteria. However, Finnish traders also viewed this as an opportunity, especially for wood biomass, because Finland has a long experience in forest certification.
- Clarity on biomass fuel quality is generally required to increase consumer's confidence, especially for wood pellets delivered to households. (Stricter enforcement of) general technical standards may be a solution. However, commodity-specific solutions to guarantee fuel quality may also be an option.

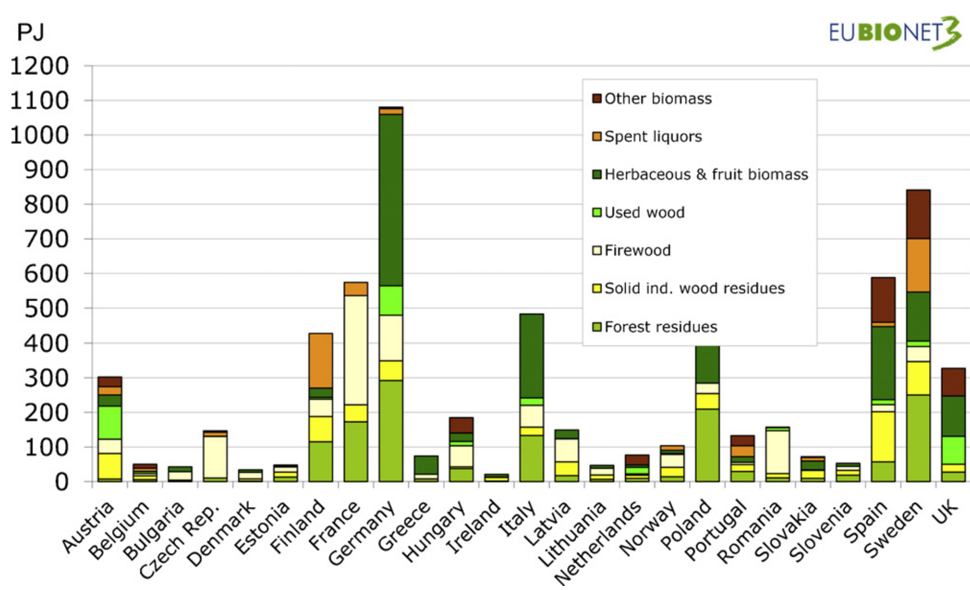


Fig. 2. Biomass resources by type in the EU-24 and Norway [1].

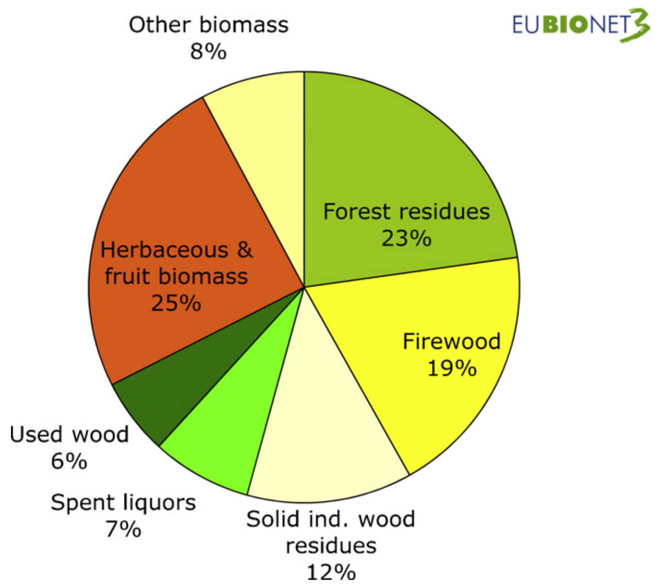


Fig. 3. Biomass resources by different types in the EU-24 and Norway [1].

Refined biomass fuels (especially pellets) have been able to overcome most of these barriers (especially the logistical barrier) due to their high energy density, sufficient policy support in various countries and (initially) abundant feedstock supply [1].

The joint work with EUROSTAT in developing a wood pellet CN (combined nomenclature) code (4401 30 20) has been finalised and first European trade statistics have been published since 2009. From 2012 onwards, these will also be a corresponding HS (harmonised system) code for global use. This means that from now on trade flows of a solid biofuels can be monitored with reasonable accuracy using official statistics—a milestone in a market, which so far has not been transparent.

The EUBIONET III project has also surveyed the existing CN codes for biomass fuels. CN codes include categories for all kinds of products traded internationally. Biomass fuels are mainly classified under the following sectors: wood fuels 4410 and 4402, agro-biomass and raw material for fuels: 3101 (manure), 1213 (straw, grains and grasses), agro-industrial biomass residues (2306, 2308, 4501, 0901, 2401 and 1205) and algae (1212), liquid biofuels or raw material for fuels: 3803, 1511, 2207, 2909, 3823, 3824 and 3825, sewage and municipal waste 3825 [2].

Most of the biomass fuels can be categorised according to the existing categories. Unfortunately, trade statistics do not differentiate end purposes of the materials between energy and raw material use, it will still remain difficult to identify streams that are traded for energy purposes. In some oil products, which are also used for food the following category is used: “For technical or industrial uses other than the manufacture of foodstuffs for human consumption”. Possibly, this kind of classification could be developed for other agro-biomass, which are not used for food or feed production [2].

EUBIONET III identified torrefied biomass (usually traded as pellets or briquettes) as a new commodity, which may soon be internationally traded. Torrefaction is a mild pre-treatment of biomass at a temperature between 200 and 300 °C, which improves the fuel quality for combustion and gasification applications. In combination with pelletisation, torrefaction also aids the logistics issues that exist for untreated biomass. Torrefaction of biomass is an effective method to improve the grindability of biomass to enable more efficient cofiring in existing power stations. In the future, new codes will be needed for this product. A difficulty is that torrefied biomass can be prepared from different kinds of raw material, and thus the physical and chemical properties may vary. Torrefied pellets can be classified separately or CN codes 4401 31 “Wood pellets” and CN code 1213 000 “Cereal straw and husks, unprepared, whether or not chopped, ground, pressed or in the form of pellets” can be modified in the subheading note, specifiying that pellets can be also thermally treated before compression [2]. Furthermore, biobased pyrolysis oil (mainly produced from woody biomass) can be used to substitute heating oil or further refined to transport fuel. Current utilisation is marginal, but in case commercial application increases, it will need also an own CN code. [2].

2.4. Biomass use in “new” industrial sectors

While biomass utilisation for energy is already common for decades in e.g. the forest industry, there are many “new” industry sectors, which are either energy-intensive (e.g. metal, chemical and cement manufacturing sectors) and/or produce biomass waste streams (e.g. the food and beverage industry), and could therefore use biomass as energy carrier. Currently, the share of bioenergy in the studied industrial sectors ranges between 0.5 and 11.7% of the total energy consumption, the biggest share being in Portugal. Results show that the cement industry and food industry have good potential to increase the use of biomass and biodegradable fraction of waste in their energy production [3,4]. In many countries, especially in Scandinavia, bioenergy use is already quite well established in the chemical and mechanical forest industry. These industries are able to use their own by-products in their energy production, which makes the investments on bioenergy economically viable.

On the other hand, several other industrial sectors require large amounts of energy in their processes, but the share of bioenergy is negligible. These industries might form a great opportunity for increased biomass use in energy production, provided that the bioenergy projects are competitive compared with traditional energy solutions.

The industries investigated (plan to) use bioenergy to reduce GHG emissions, to receive green certificates, to use by-products and to improve their brand image. Still, bioenergy has not yet been as widely taken into account as fossil fuels when it comes up to finding a solution to produce energy. Some industries are not yet convinced, as many of the industrial bioenergy projects currently in service are quite new, which leads to difficulties in estimating the projects’ impact and relevance.

In some industrial sectors, such as the food and beverage industries, all or part of the by-products can be used in bioenergy production. In these industries, the share of bioenergy is somewhat bigger, but there is room for improvement. However, in many cases, other uses of the by-products e.g. as fertiliser or animal feed are more profitable. Also, high investment costs and quite complicated technologies limit the companies’ willingness to invest in bioenergy systems. In the interviews carried out, several companies expressed their interest in bioenergy systems. Many of them had already plans for new projects, but they have been postponed due to the recession in 2008.

The steel sector requires high-quality fuels for the industrial processes, which many common biomass fuels do not meet. One possible solution for those industries could be replacing coal with torrefied wood. The largest potential for increased bioenergy use lies in the cement industry, where the requirements for fuel quality are not so strict. In the cement industry, however, the energy consumption is so enormous, that even a small percentage of biomass in the fuel mix would require such large amounts that the security of fuel supply may become a major obstacle.

Concluding, in general, the new industries are interested in bioenergy and willing to make their image greener, but the practical problems such as lack of infrastructure, insecurity of biomass supply and high fuel prices tend to limit the realisation of

investments. In many countries there is also a lack of skilled labour and knowledge on the new technologies.

As shown in Section 2.2, the largest unused biomass potential can be found in fruit and herbaceous biomass fractions. As the insecurity of fuel supply has been a major bottleneck, there is a need for further research to investigate if the fruit and herbaceous potential could be a solution for the new industries.

3. Price mechanisms and wood fuel price indexes

With the growing demand for renewable energy, European wood energy markets have continuously increased in size from the early 1990s to the present. In 1990, the share of "biomass & wastes" in the energy consumption of the EU-27 countries was 2.7%. This share had doubled to 5.4% by 2007. Since the lion's share of the fuels included in the "biomass & wastes" category consists of wood fuels, this means that wood as an energy source is increasingly becoming a more important part of the European energy system. As the use of wood energy has grown, the structure of wood energy markets has changed. What was once primarily a local or regional fuel – in the sense that production and consumption was geographically proximate – is gradually changing into an internationally traded energy commodity.

The lack of market information has been pointed out as an important barrier to further development of trade in biomass for energy. If there is no readily accessible information on available quantities, trade flows and price levels, this presents a major obstacle to market actors aiming to trade the commodity. Important strategic decisions may have to be taken without sufficient knowledge of market conditions. In order to avoid this, large amounts of financial and human capital need to be invested in acquiring market information for specific business transactions. Neither of these options represents an effective means of business conduct. Furthermore, "[market] transparency is the enemy of trading margins" and increased availability of market information is a vital step on the path towards a fair, competitive and efficient market.

To increase quality of available wood fuel price statistics, a survey collecting wood fuel prices for a majority of the European countries was conducted. The aim of the work leading up to the working paper: Wood fuel price statistics in Europe [6] has been to use the network of partners participating in the EUBIONET III project to compile a database of price statistics on wood fuels from as many European countries as possible. By making up-to-date as well as historical wood fuel prices available to a broader audience, this work will hopefully make a contribution towards increasing the level of transparency in the European bioenergy market. Besides presenting the collected price statistics, the working paper also briefly discussed the level of availability and quality of wood fuel price statistics in the EUBIONET III partner countries [6].

Despite this growth in both market size and geographical extension, there is in general a lack of knowledge concerning how wood energy markets function. This is especially true for issues regarding wood energy price development and price formation. In the background report "Price mechanisms for wood fuels" [5], several aspects of wood energy price formation and price mechanisms are highlighted and discussed, with special focus on the effects of new raw materials and international trade in wood fuels. Actual price levels in different European countries were also discussed.

Two partner surveys were made [6], first one in the spring of 2009 to gather availability and quality of wood fuel price statistics in the European countries, and secondly in early 2010, complemented in early 2011, a questionnaire for collection of price statistics for (mainstream results in brackets):

- wood pellets (residential market, bulk delivery) (9–13 €/GJ, 32.4–46.8 €/MWh),
- wood pellets (residential market, bags) (7–14 €/GJ, 25.2–50.4 €/MWh),
- wood pellets (industrial market) (7–12 €/GJ, 25.2–43.7 €/MWh),
- wood briquettes (residential market) (7–15 €/GJ, 25.2–54.0 €/MWh),
- wood briquettes (industrial market) (6–9 €/GJ, 21.6–32.4 €/MWh),
- wood chips (residential market) (4–7 €/GJ, 14.4–25.2 €/MWh),
- wood chips (industrial market, Fig. 4) (3–6 €/GJ, 10.8–21.6 €/MWh),
- firewood (residential market, broadleaved) (3–9 €/GJ, 10.8–32.4 €/MWh), and
- sawmill by-products (2.5–4.5 €/GJ, 9–16.2 €/MWh).

Prices have been collected to cover the period of second half of 2006–2010 [6].

Needless to say, there are great differences between European countries with regard to availability of statistics and whether these are compiled in an orderly and standardised manner or not. This depends to a large degree on the level of development of biomass energy in the respective countries. A review of the situation in the partner countries who responded to the initial survey, based on the contributions from the country representatives is presented in the working paper [6]. By raising this issue, the EUBIONET III project hopes that statistics agencies on national and European level, as well as bioenergy business organisations, are made aware of possible flaws in the price statistics and are encouraged to contribute to increase the quality of statistics. This is crucial for the future development of the European bioenergy market [5,6].

As for the specific factors driving wood fuel price development, it is important to note that there is a distinction between factors that affect prices in the long and short run. For example, it is sometimes casually said that bioenergy prices rise because of higher oil prices. This is in one sense a valid statement, but it is important to be aware of the fact that this statement only seems to be true in a period over one or several years, whereas there is little connection between e.g. the prices of crude oil and wood pellets if one looks at short-run price variations. In the long run, it is natural to expect that high oil prices increase the incentive to use alternatives such as wood pellets, which in the end increases pellet demand and pushes prices upwards. This is a process that involves investments in new equipment and other long-term decisions and hence it is not strange to find a lag of a year or more between oil price hikes and subsequent increases in bioenergy prices. However, the connection to the prices of alternative fuels is likely to be substantially more important in the large-scale industrial sector, which is more fuel flexible and can potentially switch between coal and wood pellets depending on the prices of the respective fuels (and emission permits). Co-firing of wood pellets with coal in large-scale power stations is already an established practice in the Benelux countries and there is great potential in Europe for expansion of wood fuel co-firing. The potential for fuel switching between coal and e.g. wood pellets is likely to lead to a correlation between prices of the two fuels. This development is further supported by technological developments in the wood fuel sector, especially the expected commercialisation of torrefied pellets.

The factor that hitherto has been dominant for the short-term development of wood fuel prices has been production costs. A clear example of this was seen in the wake of the financial crisis in late 2008 and early 2009, when prices of oil, coal and natural gas plummeted but the prices of wood fuels instead increased. The cost of purchasing raw materials is the biggest part of production costs of refined biomass fuels such as wood pellets. The traditional

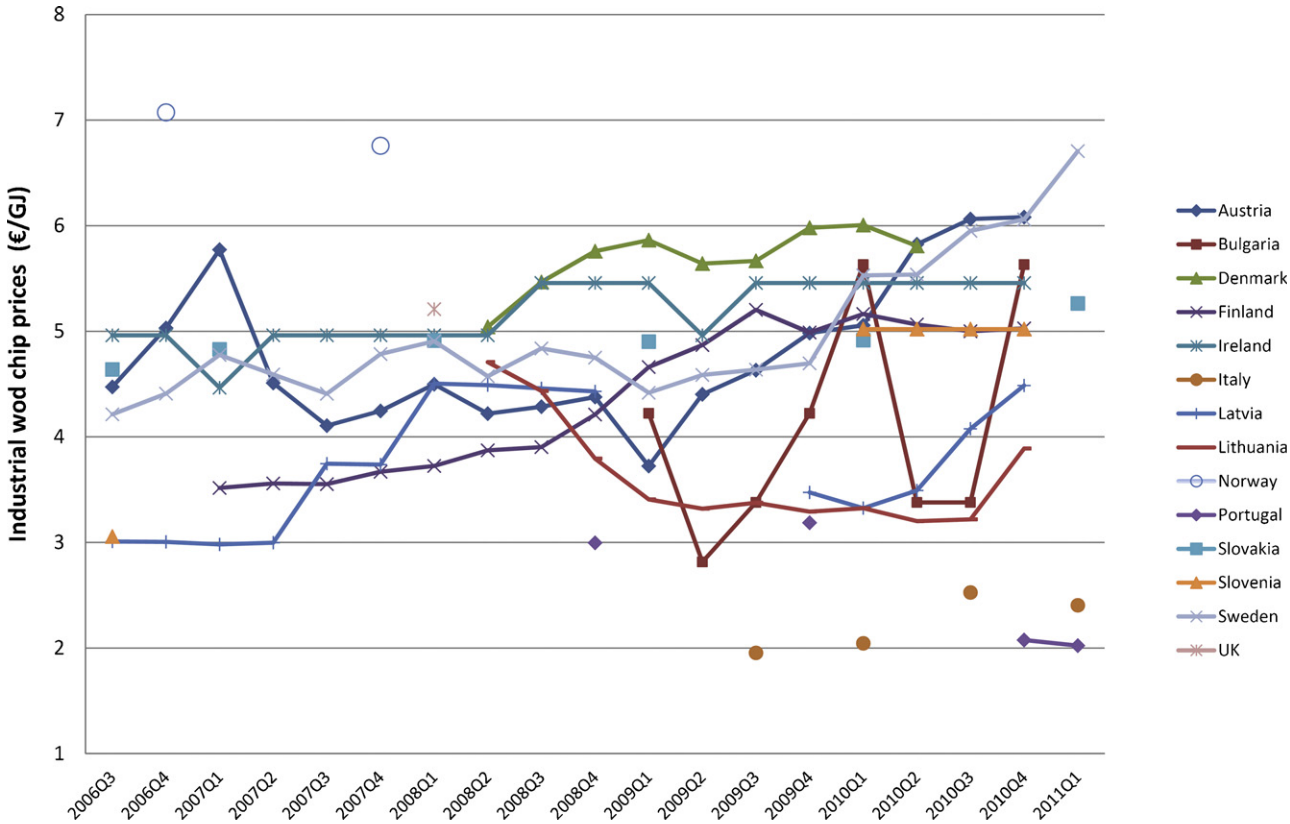


Fig. 4. Price development of industrial wood chips, €/GJ (=3.6 €/MWh) [6].

and "easy" raw materials base for wood pellet production (mainly sawdust) is now starting to become scarce, leading to increased interest in other raw materials. However, the introduction of untraditional raw materials need not automatically lead to higher wood pellet prices as this is a factor that depends much on competing demand for the new raw materials from other industrial sectors. The increased demand for raw materials for wood pellets will, however, most likely lead to more discussions about the competition for round wood and saw mill by-products between an energy sector continuously demanding more fuel and a pulp and paper industry struggling with a weak market, especially for products such as newsprint [5].

International trade has only begun to change the nature of wood fuel markets. As trade in wood fuels increases, factors such as freight rate and exchange rate fluctuations will become increasingly important. Hence, the future development of national and regional wood fuel prices is likely to be affected by plenty of issues that by no means will be limited strictly to local supply/demand balances. Petrol consumers are by now not surprised by increased prices at the pump being explained as ripple effects from developments in the crude oil market, be it unusually cold weather in the North-East US, droughts in Venezuela or hostilities in the Niger Delta. Although it may take some time before e.g. the wood pellet market has reached this level of internationalisation and interconnectedness, the speed at which the wood fuel market is developing is a harbinger that the truly global wood fuel market might not be that far into the future [6].

EUBIONET III has worked with biomass prices and price indexes since 1999. The aim is to enhance regularly price collection for most important biomass fuels [6]. In the last few years, commercial indexes have appeared such as Argus Biomass Markets [7], APX-Endex [8] and FOEX Indexes Ltd [9], see also Fig. 5. These indexes cover wood pellet markets in different parts of Europe (e.g. CIF Rotterdam and the Baltic Sea Area) and parts of North America. EUBIONET III project has cooperated mainly with FOEX Indexes on price and pellet quality issues [10]. In October 2010 FOEX and WRI[1] have agreed to partner in the launching of global wood chip price indexes. Such developments again show that the trade in refined and unrefined biomass is slowly maturing, but bioenergy markets are still far away from fully developed energy markets such as the oil market.

4. Sustainability of solid biomass fuels and standardisation

4.1. Sustainability questionnaire

Sustainable production, trade and use of solid biomass is becoming increasingly important, as several EU countries such as Belgium and the UK have already introduced mandatory sustainability requirements, and the EC may consider to introduce EU-wide criteria after 2011. One of the EUBIONET III objectives was to make an inventory of views from stakeholders on the necessity of sustainability certification systems and provide an overview of the current state of the art of different sustainability criteria and certification standards in the European Union.

For the first aim, a questionnaire on sustainability criteria and certification was distributed by all EUBIONET III partners. This questionnaire analysed the ongoing development of sustainability criteria for solid and liquid bioenergy in the EU and further actions needed to come to a harmonisation of certification systems, based on EU stakeholder views. The questionnaire, online from February to August 2009, received 473 responses collected from 25 EU member countries and 9 non-European countries; 285 could be used for further processing [11]. A large majority of all stakeholders (81%) indicated that a harmonised certification system for biomass and

[1] World Resources International LLC.

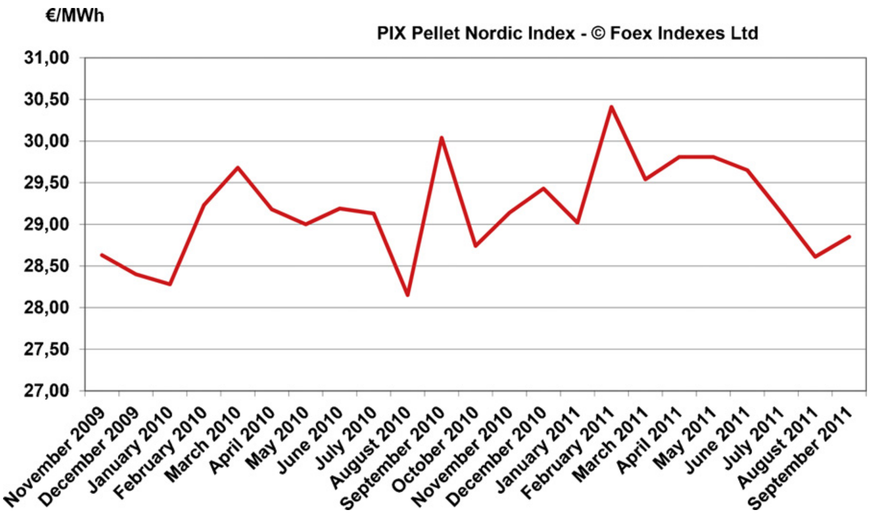


Fig. 5. Price development of industrial wood pellets (€/MWh) during November 2009–August 2011. *Note*: 1 €/MWh equals to 0.28 €/GJ. *Source*: FOEX Indexes Ltd.

bioenergy is needed, albeit some limitations. Amongst them, there is agreement that:

(i) a criterion on 'minimisation of GHG emissions' should be included in a certification system for biomass and bioenergy,
(ii) criteria on optimisation of energy and on water conservation are considered of high relevance (see also Fig. 6).
(iii) most of respondents prefer the mass-balance system or the track-and-trace for determination of the chain of custody (CoC).
(iv) the large variety of geographical areas, crops, residues, production processes and end-uses limits development towards a harmonised certification system for sustainable biomass and bioenergy in Europe,
(v) making better use of existing certification systems and standards improves further development of a harmonised European biomass and bioenergy sustainability certification system, and
(vi) it is important to link a European certification system to international declarations and to expand such a system to other world regions.

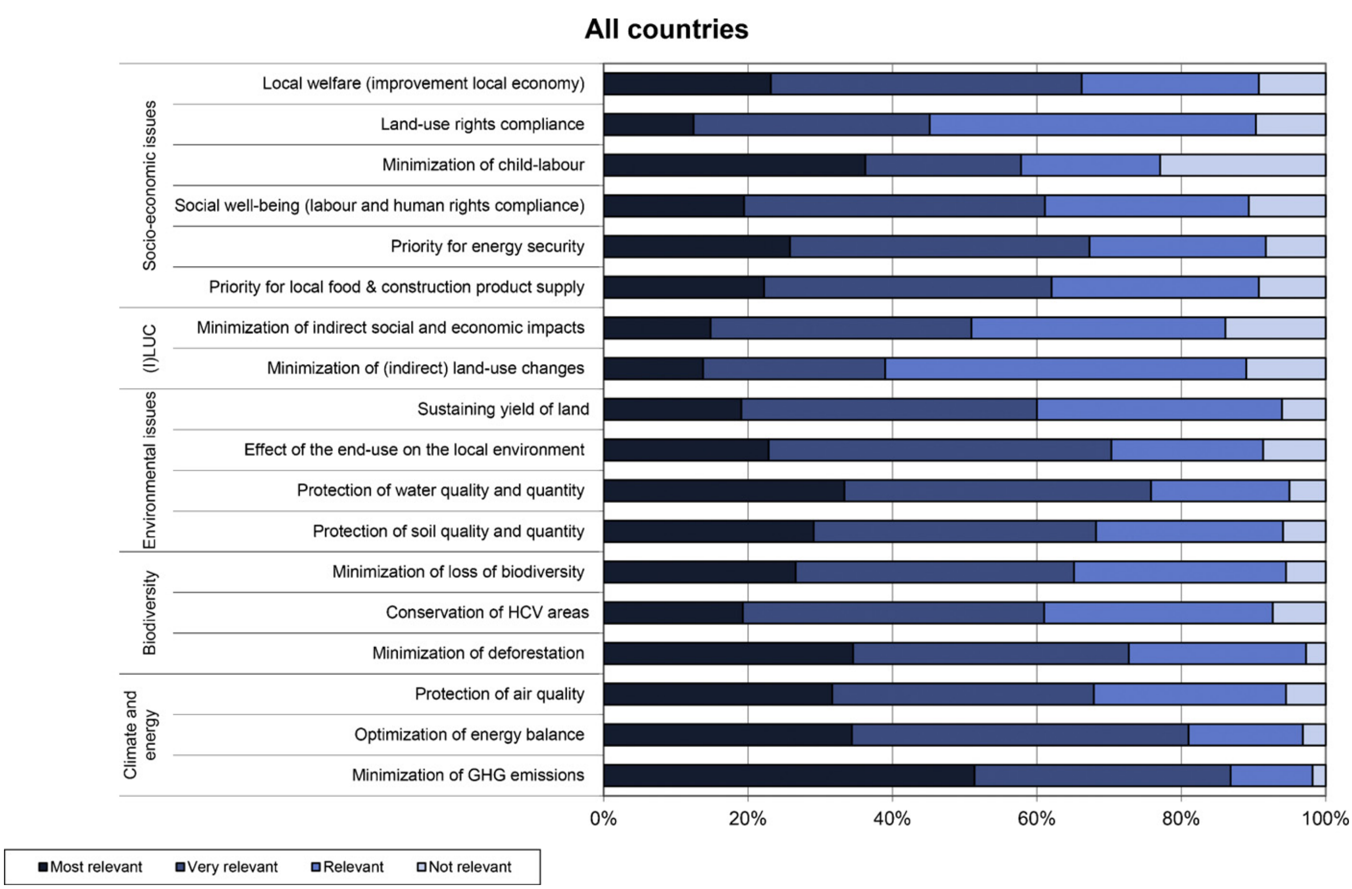


Fig. 6. Total response in all countries to indicate the importance of sustainability criteria to include in a biomass and bioenergy certification system [11].

4.2. Survey of existing national and international sustainability criteria

Furthermore, existing certification systems and sustainability criteria are likely to have different and partially contradicting methodologies. For the market, the variety of the certification systems is confusing and for biomass producers it can be difficult to find the right certification system, which satisfies the needs of clients but does not require too much costs and work. Therefore, in an evaluation, 44 different national and international systems and initiatives to guarantee to sustainability of biomass were compared and analysed [12,13]. Some of the initiatives are developed for organic agriculture, some for sustainable forestry management and only a few are developed to certify biomass for bioenergy purposes. The scope of the initiatives differs and the geographical coverage varies for each of the initiatives. The scope of many (national) initiatives lies on organic agriculture and does not include greenhouse gas emissions or social issues. Also forestry, with long experience on certification issues, has not included the GHG emissions along the product life chain in the criteria for sustainable wood [12,13].

Only the newly developed certification systems specifically for bioenergy, such as the UK's Renewable Transport Fuel Obligation (RTFO), the Dutch standard NTA8080, the International Sustainability and Carbon Certification (ISCC), the Round Table on Responsible Soy Association (RTRS) and the Roundtable on Sustainable Biofuels (RSB) covered all sustainability requirements defined by the European Union.

To reduce the complexity it would be easier, if the amount of different systems would be reduced. Also, a comprehensive bioenergy sustainability certification system should not be based on a single crop (examples the roundtable on sustainable palm oil (RSPO), the round table on responsible soy association (RTRS)), the type of the bioenergy (solid or liquid, as example the EC sustainability criteria) or the application (transport, heating, food e.g. for transport the UK's renewable transport fuel obligation (RTFO)) [12,13]. For example, the forestry certification systems FSC and PEFC do not include greenhouse gas emission criteria. The focus of FSC and PEFC lies on other use of wood than energetic, but as forestry is the largest bioenergy supplier in the European countries, the inclusion of the GHG-emissions in the forestry certifications should be discussed in the future. Only in Finnish forest certification system there are special requirements for energy wood [12,13].

It is too early to estimate, if the audits and verification systems can guarantee a sustainable production of biomass for energy purposes or if the difficult problems of indirect land use change or GHG emission calculation method still affect the credibility and interest of the stakeholder on the initiatives. Summarising, measuring and quantifying sustainability of bioenergy is a very complicated issue. The meaning of sustainability can be defined in different ways, depending of the context and of own values and interests. It is almost a philosophical question how to measure something, whose three dimensions (environmental, social, and economic) sometimes are even in conflict with each other. In the long run, the aim could be to develop some basic principles, which apply for all agriculture to guarantee a sustainable land use and agriculture in aim to produce bioenergy. For different energy crops there could be several sub-standards to meet the special needs of each application. It could be even considered to expand sustainability certification not only to all bioenergy, but also to all biomass usage. Food, fodder, and industrial use could be included and sub-standards under the general principles formulated [12,13].

4.3. Supporting CEN standardisation of solid biofuels

The EUBIONET III project also carried out a survey on the industrial wood pellet product standard. Many industrial pellet users have proposed similar product standard as EN 14961-2-Wood pellets for non-industrial use. In this standard properties are bind together to form classes: A1, A2 and B. EN 14961-2 standard is approved and will be published 15 June 2011. The draft ENplus by the European Pellet Council (EPC) and DINplus certification handbook was also disseminated to partners and other target organisations. The aims of the questionnaire were to find out [14]:

- if a special industrial pellet product standard is needed
- to collect proposals regarding what this standard should include
- if certification system for industrial pellets is needed and if this certification system should include sustainability issues
- what are the raw material requirements e.g. can chemically treated material be accepted
- if standard for thermally treated biomass e.g. torrefied pellets is needed

Feedback was gathered from 44 responses representing different European countries and Canada, including 18 producers, 17 end-users and 13 other organisations like associations and certification bodies. It should be noted that 5 respondents had multiple roles e.g. function both as a producer and an end-user [14]. All large consumers of industrial wood pellets (utilities with coal power plants in several EU-countries) replied to the questionnaire.

Most of the respondents replied that they were going to use EN 14961 standards (60%), while 27% are not going to use it (see also Fig. 7). 39% of the respondents found separate industrial pellet standard important, but the same percentage also indicated that such a standard is not necessary, or that the EN 14961-1 standard could be used with some additional parameters. Roughly the same result was found for torrefied pellets. 49% of the respondents found that a certification system is needed whereas 36% thought it was not needed. Sustainability certification was especially found important in the Netherlands, UK and Belgium. Most respondents from the Nordic countries and some Central European countries did not find this necessary, because raw material comes from certified forests. While 50% of the respondents did not support the use of chemically treated material, 32% supported the use of small amounts of chemically treated material e.g. glued wood, but only if the combustion technology and flue gas cleaning system is advanced. Most of the respondents would not allow chemically treated raw material to be used in pellets destined for domestic consumers [14].

Note that the ISO/TC 238 working group 2 is currently preparing the standard ISO 17225-1 "General requirements". The creation of a single master table for thermally treated biomass is proposed at the moment. Torrefied pellets could be classified under this pellets table by adding some additional property classes for bulk density, fixed carbon and moisture content. Torrefied pellets are not yet a common bioenergy commodity, so it is too early to set many property classes and values for them. The table should be very general and flexible [14].

While drafting the product standard EN 14961-2 for non-industrial wood pellets, some of the power producers already commented that a similar table should be available for industrial use, too. The ISO product standard under preparation (ISO 17225-2 "Graded wood pellets") will include also separate tables for non-industrial and industrial use. Proposals for threshold values collected by EUBIONET III will be disseminated to the ISO/TC 238 working group 2 for discussion. The ISO/TC 238 working group is drafting solid biofuels standards during 2011 and 2012, and the results of this questionnaire are to be discussed during the next ISO meeting in Thailand in November 2011 [14].

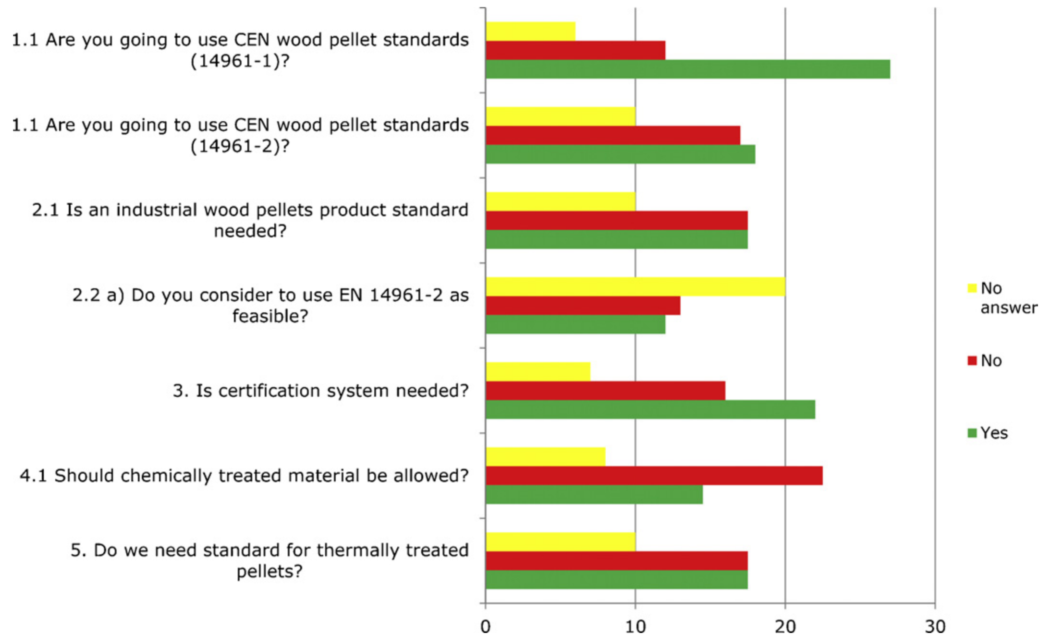


Fig. 7. Summary of the replies for different questions [14].

5. Agro-industrial residues—an unexploited bioenergy resource

In the past years, there is an increasing debate regarding the use of energy crops for e.g. liquid biofuels production. One of the criticisms is whether it is improper to use crops that can be used for food or feed. Furthermore, in the next decades, a huge pressure on the "traditional" biomass resources like wood and straw can be expected, because many EU countries plan to use these types of biomass for energy, as laid down in the national renewable energy plans (NREAPs) published in 2010 [15].

In the EUBIONET III project, the aim was to scan the European market for unexploited "alternative" biomass resources. The main focus was on agro-industrial residues, although also other biomass was included in the inventory. Also, the aim of EUBIONET III project was to point out ways of improving fuel characteristics of the agro-industrial biomass resources [15]. For each country, the project partners reviewed existing biomass surveys, identified possible gaps, and collected data from industry through their own network of contacts. The data in the project are based on partners' contacts in EU countries as well as project participants' estimates of the total potential on the basis thereof.

The results indicate that there are considerable unexploited resources. The actual amount reported by EUBIONET III partners correspond to an energy potential of approximately 100 PJ (2.4 Mtoe)—is still the basis of biomass, which was identified through direct contacts with the industry [15]. Based on these amounts, each partner estimated a total potential for the entire country. These estimates amounted to a total of approximately 250 PJ (6 Mtoe) in 17 European countries (see also Fig. 8). Given the fact that some EU countries with a large agricultural sector were not assessed (e.g. France), the total EU potential is likely to be even large [15,16]. Previous experience from a scan of the Danish market shows a potential of about 500,000 tons of agro-industrial residues alone. As a first-order estimate, if this is scaled up to European level (based on the number of inhabitants) the potential is estimated to be around 750 PJ (17.9 Mtoe). This is equivalent to slightly less than the total annual energy consumption in Denmark [15]. However, it needs to be pointed out that the amount of agricultural activity per capita differs amongst EU member states, so this should only be seen as a rough approximation.

In Southern European countries (Greece, Italy, Spain and Portugal) residues from olive production are by far the largest resource. It has been difficult for the partners from these countries to provide precise assessments of the volume, but based on an overall olive harvest of just over 10 million tons, the annual amount of residues would be more than 7 million tons, equivalent to a theoretical energy potential of more than 150 PJ. It should be mentioned that the energy utilisation of olive waste is already growing rapidly, as well as for nuts (almond, hazel, etc.) shells that in Southern Europe is becoming an interesting potential energy resource, presently already used in substitution of wood pellet fuel into small scale stoves and boilers [15].

Another large resource is grain screenings, at the European level assessed at a theoretical potential equivalent to 40 PJ (1 Mtoe). Other biomass types could be residues from breweries, the tobacco industry and plant oil (besides olive oil) production e.g. sunflower shells, sheanut shells, etc. [15].

While the technical potential of agro-industrial residues is likely to be significant, their commercial exploitation (and exploitation of other "alternative biomass") is not without challenges. Firstly, often, these biomass types generally have a high water and/or ash content, and their chemical composition may cause problems during combustion. Therefore, it is important to select the conversion technology, which is best suited for the product (i.e. combustion, fermentation, gasification, etc.). Secondly, it is possible to improve the fuel characteristics of the agro-industrial biomass in several ways, depending on the type of conversion to be used. For combustion/thermal gasification, the following methods are amongst the most applicable [5]:

- "Washing" of the biomass can remove a substantial part of the difficult substances in the biomass (i.e. potassium and chlorine in straw)
- Using additives for slag abatement/prevention of deposit formation, including:
- Combustion catalysts; in order to improve the combustion
- Coating inhibitors; intended to prevent sulphur related coatings

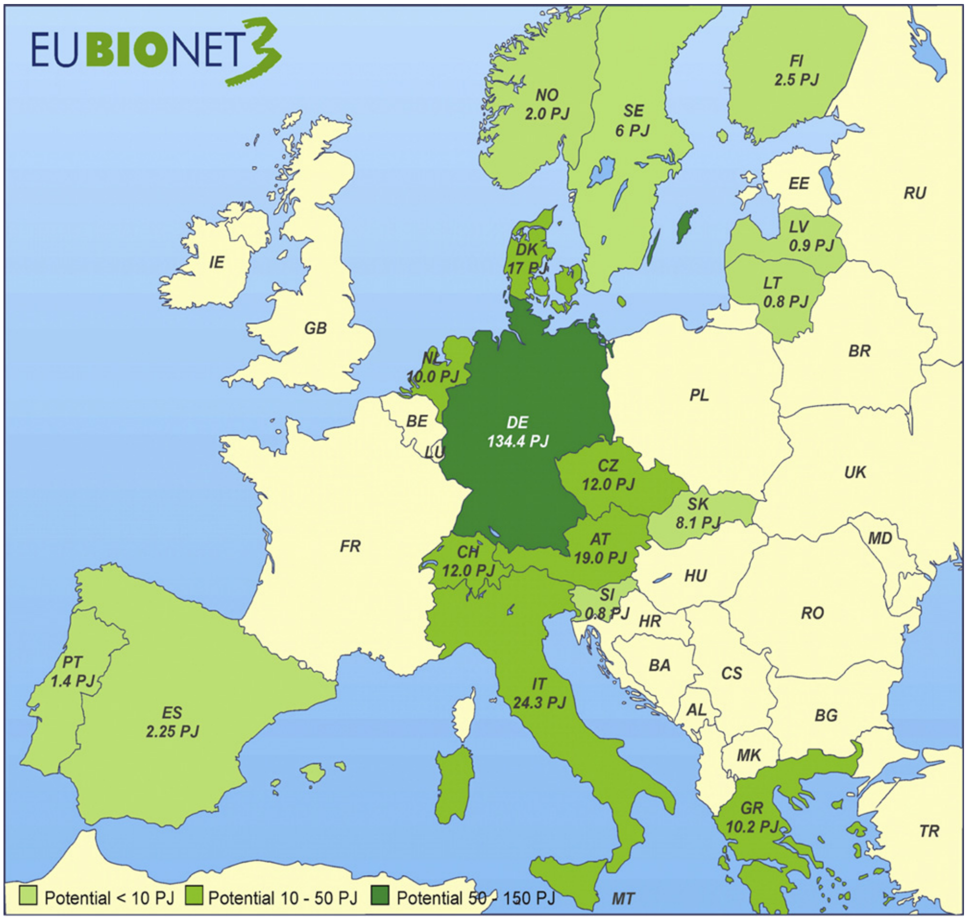


Fig. 8. Amounts of unexploited agro-industrial residues in selected EU member countries as estimated by EUBIONETIII project partners [15].

- Corrosion inhibitors; used to prevent chlorine and aerosol related corrosion and fouling

For conversion methods, in which biological or biochemical processes are applied, different pre-treatment methods may be applied in order to improve the processes and increase the energy yield. Examples include [15]:

- Enzymatic pre-treatment; enzymes are typically used to speed up biological and biochemical processes like for instance degradation of low soluble chemical structures in the biomass.
- Thermo-chemical pre-treatment; a combination of heating and a chemical treatment (for instance with acid) can also “open” chemical structures.
- A combination of pressure and temperature (steam explosion) also results in the opening the biomass structure.
- Grinding or milling of the biomass can improve the degradability of the biomass, simply by increasing the surface of the biomass to be exposed to the microbial activity.

Finally, in order to optimise biomass logistics and supply, biomass pre-treatment is often recommendable, such as baling of straw. Other examples are [15] drying to improve storage stability, chipping to ease transport and pelletising/briquetting; to ease transport and reduce transport costs.

6. Biomass heating and cooling

The use of biomass for heat production in Europe is getting increasingly important, compared to fossil fuels, but also to other renewable energy sources. One of the main reasons is that biomass can easily be transported, stored, traded and used with several applications at the time and place where energy is needed [17]. One of the aims of the EUBIONET III project was to describe the role of heating and cooling with biomass in the EU. Due to analyses of national and European statistical data, the current status of heating and cooling with biomass and the availability of data is pointed out in a background report [17]. The actual developments in the biomass energy market are significantly influenced by European regulations. The Energy and Climate change package and the so-called 20-20-20 targets, as well as the national implementation of the targets have effects on the biomass heating and cooling sector [17]. Approximately half of the final energy demand of EU-27 is used for heating. In 2008, about 11.9% of this energy demand was covered by renewable energy sources. Estimates show that the EU-27 consumes about 55.1 Mtoe of biomass for heating, including wood, wood waste and renewable municipal wastes. The shares of biomass use for heat production in EU-27 countries are varying. Countries like Sweden, Finland, Austria, Germany or Latvia have a high share of biomass use for heat production, because of the traditional use of wood fuels in households and industries. In other countries like United Kingdom or Ireland, the share of biomass for heat is slightly increasing the last years [17].

The most common biomass fuels for domestic heat production are wood logs, wood chips and wood pellets. Especially for modern low-energy houses, wood pellets in combination with grate furnace technology are used. Wood pellets and wood log boilers are available with capacities of less than 25 kW, while wood chip boilers are produced with capacities from 30 kW up to several MW. Therefore, wood chip boilers are used for buildings with higher heat

demand and for district heating systems [17]. Cooling with biomass is currently limited to centralised district solutions. The main market for district cooling is the service sector, followed by the food and mining industry. The residential sector at present is characterised by a low demand for biomass and district cooling. Domestic decentralised cooling systems are based on air condition produced by electrically operated compressor chillers or solar power. The cooling market is currently dominated by air conditioning systems powered by electricity and the demand of electricity used for cooling is estimated with more than 260 TWh in Europe. Decentralised systems for cooling with biomass are at present not marketable and competitive [17].

The analysis also revealed that statistical data on biomass consumption for heating or cooling especially in households are rare and old. For an effective energy policy and to check developments and excepted impacts of energy efficiency measures, a regular data collection is very important. There are a number of ongoing activities to improve the data availability on European Member States level, but these are not yet readily available [17].

A second goal was to give an overview of the technical possibilities and the state of the art of heating and cooling with biomass. To provide this overview, a catalogue for small-scale biomass boiler manufacturers was created to describe the actual biomass boiler market. The most important manufacturers of biomass boilers in the respective countries were selected by each project partner and presented in company fact sheets. These factsheets of 59 boiler producers include information on contact details, form and size of the company, number of employees and turnover, market share and sold units and a short description of their products. Countries like Austria, Germany, Finland and Sweden have a very broad range of different producers for small-scale boilers. Boilers are traded within whole Europe. Especially East-European countries are concentrated on home markets and export their product limited to Europe and Russia. Producers in Austria, Germany, Finland and Sweden export their boiler within Europe, Russia, but also to North and South American Countries and also to Asian markets [17].

A third aim was to compare the costs of different heating systems. Therefore, based on actual market prices for boilers and fuels, a number of case studies were carried out to evaluate the costs when a fossil heating system is replaced by a biomass heating system. These case studies describe best practice examples and give an overall picture of the different heating situations and cost-differences between fossil and biomass fuels in European countries. The case studies also include calculations and comparisons of greenhouse gas (GHG) emissions in CO_2 equivalents of the fossil and biomass based heating system [17].

In total, 35 case studies with 67 different heating systems were carried out. These heating systems are fired with 19 different fuel types: 10 biomass fuels, 6 different fossil fuels and fuel combinations. Besides the different fuel types, the case studies also include a wide range of different boiler capacities. Wood pellet boilers represent the largest share of the heating systems evaluated: 18 case studies deal with wood pellets. The boiler capacity ranged between 8 kW and 1 MW, but most systems analysed were used in residential buildings with a capacity from 8 kW to 75 kW [17]. The second most common biomass fuel was wood chips with 12 different heating system examples. The capacities of the boiler range from 120 kW up to 3.3 MW. Wood chips are typically used in case studies of large building with a high heat demand [17]. Finally, log wood heating systems were evaluated in 8 case studies; capacities ranged from 15 kW up to 225 kW [17].

Fig. 9 shows the correlation of investment costs and boiler capacity. The investment costs increase with a higher boiler capacity for biomass as well as for fossil fuel based heating systems, but there are clear economies of scale (i.e. the specific investment costs are decreasing rapidly with increasing size). Investment costs depend on the used technology and the fuels. The cheapest systems are log wood boilers. These boilers do not have any facilities for automatic charging and expensive storage technologies [17]. The lowest investment costs for fossil fuelled heating systems are reported for gas boilers connected to the gas grid and electric heaters. These systems need no technical equipment for fuel storage [17]. Note, however, that the fuels costs are the dominant factor determining the total costs of domestic heat production. Even though the investment costs of fossil fuelled boilers are lower than for biomass boilers, the specific total costs of biomass fuelled variants are in nearly all cases cheaper [17].

Next to comparing the costs of biomass heating systems with fossil fuel systems, also the GHG emission reduction potential was evaluated. The emissions of the respective heating systems were calculated with the life-cycle-analysing software GEMIS. Fig. 10

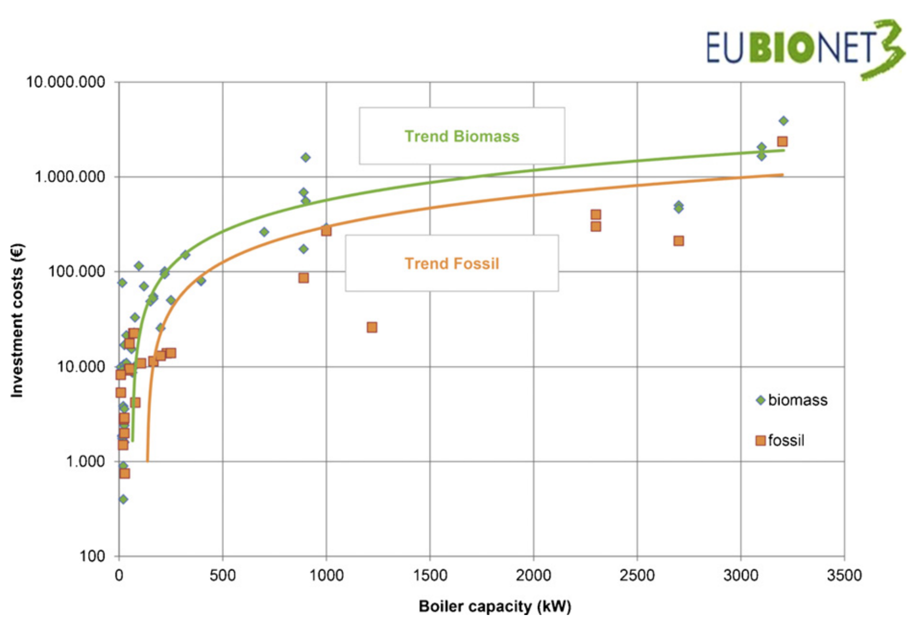


Fig. 9. Correlation of investment costs and boiler capacity of biomass and fossil fuel heating systems [17].

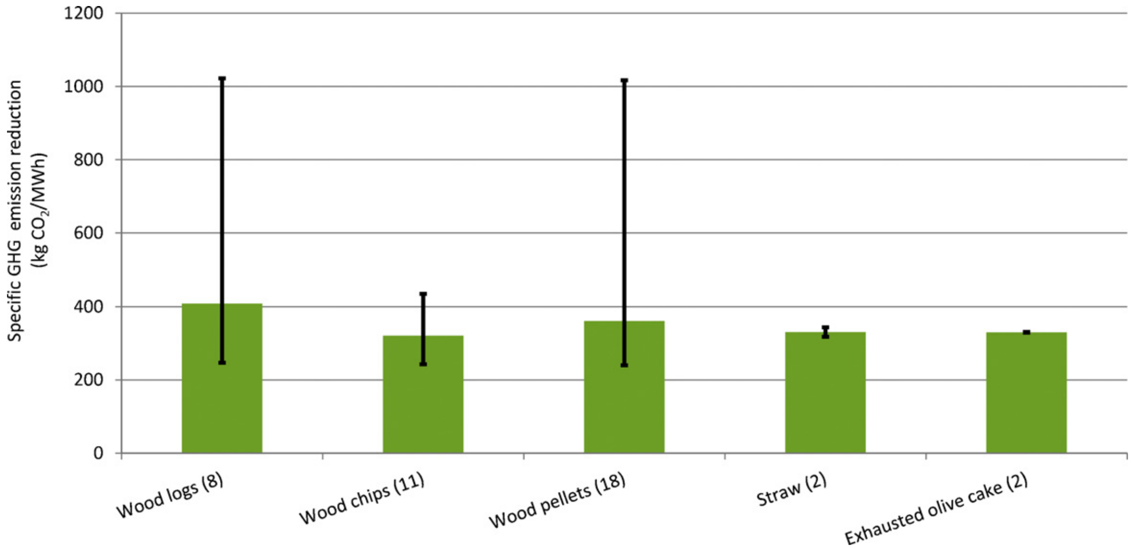


Fig. 10. Specific reduction of CO_2 emissions of selected biomass heating systems (kg CO_2 eq./MWh heat output) [17].

shows the specific reduction of GHG emissions. The error bars indicate the total range of results within the specific fuels. The partly large variations are due to different boiler capacities, technologies and heat demands [17]. The GHG reduction potential of a biomass heating system depends on the fossil reference heating system. Biomass fuels and fossil fuels based heating systems show a clear difference. Depending on the type of fuels and boiler, the potential GHG emission reduction ranges from 90% to 98% [17]. The highest reduction calculated in the case studies was more than 1,020 kg CO_2-equivalents per MWh, where an electric heater was changed by a log wood boiler. The average CO_2-equivalents-reduction for all described biomass fuels ranged from 330 kg/MWh to 410 kg/MWh. Total emissions depend also on the required heat demand. If all case studies are realised and the fossil based heating systems are replaced by biomass systems, GHG emissions of about 19,000 ton CO_2-equivalent will be avoided each year. Furthermore, even with a blend of fossil and biomass fuels for heating systems, all case studies reached a reduction potential of more than 90% [17].

7. Bioenergy and forest industry

With the increasing use of woody biomass for energy, there is a chance that competition for raw woody material has increased in the recent past, and may increase further in the future. To shed more light on this topic, aims of the EUBIONET III project were to analyse current wood flows, evaluate the effect of policy measures on the availability of woody material, and whether the currently unutilised woody biomass potential meets the requirements of the forest industry.

To show the current production, processing and consumption of wood in the EU-27, the wood flows were charted for the EU (see Fig. 11) and in each country [18]. Note that a large share of bioenergy in Europe originates from by-products and residues from the forest industry, both from mechanical and chemical processing that are not suitable for further processing for other products. Annual wood fuel use is estimated to be about 238 million solid m^3, which equals to which equals to 1715 PJ (about 41 Mtoe) and production of final products is estimated to be about 300 million solid m^3 [18]. Furthermore, it t is noticeable that a large amount of forest growth of over 300 million solid m^3 (the annual increment of wood stock) is not used [18].

A survey of legal incentives for forestry sector support showed that the majority of support actions relate to taxation, feed-in-tariffs, forestation, and thinning and harvesting support, especially for energy production purposes [19]. To evaluate the effects of policy instruments, a survey was sent to representatives of the forest industry and 38 responses were received. The survey focused on two topics:

(1) Understanding the situation with regard to competition for woody biomass between the forest industry and the energy sector, and
(2) Understanding the impacts of different policy instruments on wood availability and price levels.

Responses of the survey show that stakeholders have serious concerns regarding the future supply of wood to the forest industry at competitive prices due to the foreseen increased demand of biomass for energy use. On the other hand, decreasing the dependency of the fossil fuels was also seen as a positive development.

The inventory of available woody residues revealed that the currently unutilised resources are poor raw material for other forest industry uses. However, better statistics of wood production and use are needed. Current statistics shows great structural differences of forest biomass use between countries [19].

As shown in Table 1, at the moment, the increased competitive situation of biomass between forest industry and energy sector is not reflected in export or import prices derived from statistics at a country level. However, because a major portion of market operations is exercised inside country, there can be operators that have faced competition in their area [18]. Earlier, wood prices were mainly determined by production costs, leading to price fluctuations. Since the demand is increasing and stabilising due to energy production, the connection between wood price and fossil fuels price is expected to strengthen (Fig. 12).

8. Final summary and conclusions

The work of the EUBIONET project in the past decade has shown that solid biomass utilisation for energy purposes has grown strongly, and also has the potential to grow further in the next 10 years. Utilisation can provide an useful end-use for many biomass types, which are otherwise considered wastes, and at the same time achieve very high GHG emission reductions. Below, we summarise our main findings, including the challenges for further development and possible solutions:

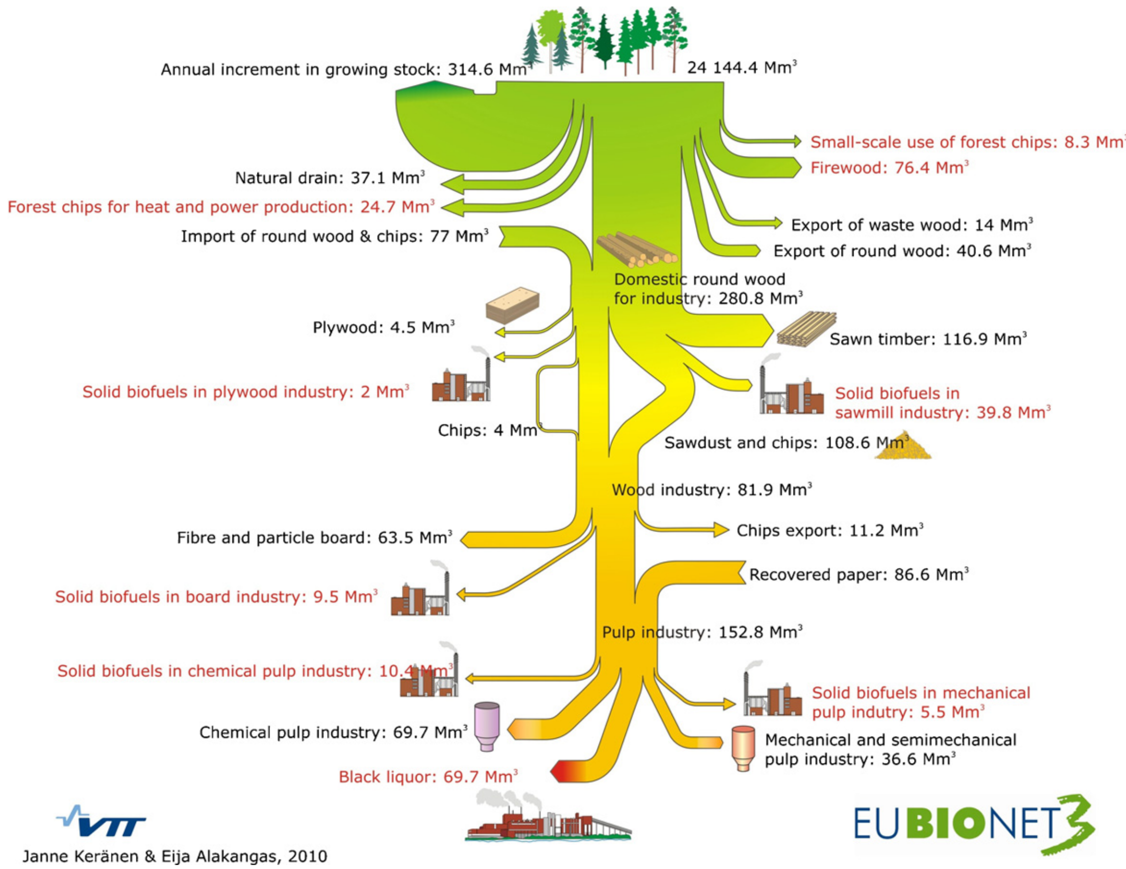


Fig. 11. Wood flows in Europe in 2008 [18].

Table 1
Apparent export and import prices of wood material in Europe (2009). The highest two values are presented in **bold**, the two lowest *in italics* [18].

	Median values			Unit
	Export value	Import value	Export – import	
Roundwood	49	50	–1	€/solid m³
Industrial roundwood	49	50	–1	€/solid m³
Chips and particles	*31*	*23*	8	€/solid m³
Recovered paper	78	99	–21	€/ton
Sawnwood	171	192	–20	€/solid m³
Fibre furnish	111	251	–141	€/ton
Wood fuel	*35*	*21*	13	€/solid m³
Wood pulp	**353**	**399**	–47	€/ton
Chemical and semi-chemical pulp	**323**	**399**	–76	€/ton
Wood residues	50	36	14	€/solid m³

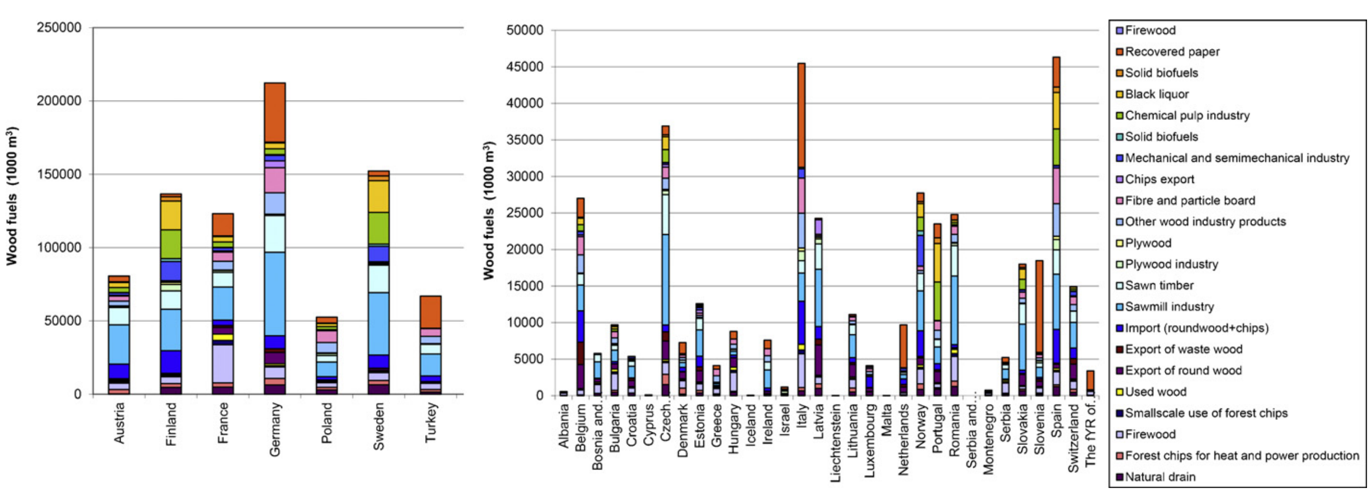


Fig. 12. Use of wood in Europe in 2008 [18].

- Only about half of the solid biomass potential in Europe is currently utilised. Both agro-industrial and woody biomass potentials remain unutilised, and could offer important growth opportunities for the coming decade. Challenges are (fear for competition with) other uses, the fact that the existence of many of these resources is unknown to possible users, and logistical and economic barriers. "New" users could include energy-intensive industries like chemical, metal and cement industries, but also the food processing industry has room for increased utilisation.
- Compared to fossil fuels, many solid biomass fuels remain bulky and difficult to handle—more research into advanced pretreatment and handling is needed.
- Internationally traded solid biomass volumes are growing rapidly. With this growth, we observe the first signs that this market is maturing e.g. due to the establishment of trade statistics for wood pellets, and the creation of several wood pellet price indexes. However, the refined solid biomass markets still have a long way to go before they reach the level of fossil fuels (both in terms of volume, and in available hedging tools, trade platforms, etc.). Prices of refined and unrefined solid biomass currently still differ widely amongst EU member countries, but international trade may help to level these differences.
- Sustainable production of solid biomass is becoming more important, especially as many biomass resources are becoming scarce, and dedicated energy crop plantations (both in the EU and outside) may become an increasingly utilised source. Criteria such as GHG emission reduction, energy balance and water use are deemed important aspects to take into account. There seems to be agreement amongst a majority of European stakeholders that a harmonised certification system is needed, although under a number of preconditions, and devising such a system is a challenging task.
- Solid biomass is used largely for heating (and to a small extent cooling) in the EU – and is able to realise very high GHG emission reductions compared of fossil fuels at almost no additional costs – a situation, which differs strongly compared to e.g. liquid biofuels for transport.

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[2] EUBIONET III website includes national reports of different subjects, event reports and presentations of the events, flyers of main results and summary reports of different topics. All reports and other material are available at http://www.eubionet.net/.